

Structural characterization of natural rubber to improve its quality

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Abstract—Natural rubber (NR) latex shows considerable variation in composition and colloidal structure as the result of biological, geometric, climatic and other influences. These varieties originate the inconsistency in the properties of latex and solid rubber, which are the causes of difficulties in processing latex to well-defined products with uniform properties. Another point should to concern as a major point affecting the inconsistency of NR is the change in the structure of NR such as the branching and gel formations during storage. Therefore, this project will be an attempt to elucidate the fundamental knowledge on microstructure and other chemical properties for improving the consistency of NR.

It was found that rubbers from regularly tapped mature trees with different ages of rubber trees showed similar in chemical and physical properties. The particle size of NR was 0.2-3 μm , which the larger particle size was in pear-shape. The highest stability of rubber particles was observed at pH 9. By OM and SEM techniques, rubber particles were aggregated after removal of protein and phospholipids layers due to the loss of colloidal properties. It was found that protein on rubber particles was smaller size than that in serum phase, whereas the protein obtained from different ages of rubber trees showed the different in molecular weight. The relationship between rubber particle sizes obtained by different centrifugation speed of rubber cream and their properties was elucidated. The small rubber particles (SRP; size < 250 nm), was found to compose of both low and high number-average molecular weight (M_n) rubber molecules, while larger rubber particles (LRP; size >250 nm), mainly consisted of low M_n rubber molecules. The ester content in SRP was lower than that of LRP, indicating that LRP contains mainly rubber molecules terminated with a functional group containing fatty acid ester groups and SRP is mainly consisted of linear molecule. The microstructure of terminating-end (α -terminal) was elucidated by selective decomposition of ester linkages with enzymatic reactions using lipase, phosphatase and phospholipases followed by a combination with ^1H -, ^{13}C - and ^{31}P -NMR analyses and molecular weight by GPC. The α -terminal of rubber molecule was postulated to be mono- and diphosphate groups linking to phospholipids by Mg^{2+} and hydrogen bonding. Mg^{2+} , tetramethylthiuram disulfide (TMTD), zinc oxide (ZnO) and diammonium hydrogenphosphate (DAHP) were the origin of additional branching-points in long-storage fresh and commercial high-ammonia lattices. In addition, the structure of initiating-end (ω -terminal) in *Hevea* rubber was analyzed by using polyprenols isolated from *Hevea* shootings and fresh BF as well as low molecular weight rubbers. By NMR analyses, polyprenol and low molecular weight (MW) fraction of washing the cream fraction from fresh latex with surfactant (WRP) showed the presence of dimethylallyl group and two-*trans* isoprene units. This finding suggested that the initiating species of NR is *trans,trans*-FPP, as in the case of two-*trans* polyprenol. The storage-hardening (SH) of the purified NR was analyzed under accelerated low humidity conditions. The fatty acid ester groups was found to play the most important role in the gel formation and SH of rubber under low humidity condition. Base on the transesterification and ethanol/toluene mix solvent treatment, the gel phase in NR is mainly originated from micelle formation between phospholipids and partly formed from hydrogen bonding by proteins in rubber chains. Highly purified NR was prepared by saponification of latex with NaOH followed by soaking the coagulum in aqueous NaOH. The extract from saponified NR (SAP-NR) and soaked SAP-NR was confirmed to be free from allergic proteins and no extractable protein by ELISA method with FIT Kit. SAP-NR showed a small extent of SH compare to FNR, suggesting the high consistency properties NR.

Keywords— natural rubber, initiating-end, terminating-end, branching, storage-hardening
Outputs

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